

CLAIMS

1. A method of operating an electrochemical fuel cell having an anode, an ion transfer membrane and a cathode, comprising the steps of:
 - 5 delivering fluid fuel to fluid flow channels within the anode;
 - delivering fluid oxidant to fluid flow channels within the cathode;
 - exhausting reaction by-products and any unused oxidant from the fluid flow channels within the cathode; and
 - 10 delivering a sufficient quantity of liquid water to the fluid flow channels within the cathode such that a relative humidity of 100 % is maintained substantially throughout the fluid flow channels.
2. The method of claim 1 in which the step of delivering a sufficient quantity of liquid water comprises determining a maximum in cell voltage as
15 a function of liquid water flow rate and delivering at least a minimum water flow rate corresponding to said cell voltage maximum.
3. The method of claim 1 applied to a plurality of such cells in a fuel cell stack, in which the step of delivering a sufficient quantity of liquid water
20 comprises determining a maximum in stack voltage as a function of liquid water flow rate and delivering at least a minimum water flow rate corresponding to said stack voltage maximum.
4. The method of claim 1, claim 2 or claim 3 further including the step
25 of increasing the quantity of liquid water delivered as a function of cell or stack current to maintain a water factor $WF > 1.0$ for all currents within a normal operating range of the cell or stack.
5. The method of claim 2 in which the step of delivering a sufficient
30 quantity of liquid water comprises:

determining a maximum in cell voltage as a function of liquid water flow rate for each of a plurality of cell currents that correspond to a normal range of operating conditions of the cell,

- determining a calibration function expressing minimum liquid water flow rate as a function of current and/or air stoichiometry, and

delivering at least said minimum water flow rate, for the current drawn from said cell and/or for the air stoichiometry, as determined by the calibration function.

6. The method of claim 3 in which the step of delivering a sufficient quantity of liquid water comprises:

determining a maximum in stack voltage as a function of liquid water flow rate for each of a plurality of stack currents that correspond to a normal range of operating conditions of the stack,

- determining a calibration function expressing minimum liquid water flow rate as a function of current and/or air stoichiometry; and

delivering at least said minimum water flow rate, for the current drawn from said stack and/or for the air stoichiometry, as determined by the calibration function.

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7. The method of claim 5 or claim 6 in which the calibration function is determined for air stoichiometry in the range 1.1 to 10.

8. The method of claim 7 in which the calibration function is determined for air stoichiometry in the range 1.4 to 4.0.

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9. The method of any preceding claim in which the step of delivering a sufficient quantity of liquid water comprises delivery of a water factor of at least 1.5.

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10. The method of claim 9 in which the step of delivering a sufficient quantity of liquid water comprises delivery of a water factor of at least 3.
11. The method of claim 9 or claim 10 in which the step of delivering a
5 sufficient quantity of liquid water comprises delivery of a water factor of less than 40.
12. The method of claim 11 in which the step of delivering a sufficient quantity of liquid water comprises delivery of a water factor in the range
10 from 3 to 6.
13. The method of any preceding claim further including the step of temporarily permitting delivery of a quantity of liquid water to the fluid flow channels within the cathode such that a relative humidity of less than 100 %
15 is maintained when the cathode exhaust temperature is below a predetermined threshold corresponding to a sub-optimal operating temperature.
14. The method of claim 13 applied upon start up of the fuel cell or fuel
20 cell stack.
15. The method of claim 1 in which the fuel cell is operated such that, for any measured cell power delivery, liquid water injection rate into the cathode and / or gas flow through the cathode are controlled to ensure that
25 there is more liquid water at all regions of the cathode surface than can be evaporated in the prevailing temperature and pressure conditions.
16. The method of claim 15 applied to a plurality of such cells in a fuel cell stack having a common oxidant supply manifold and a common water
30 injection manifold such that, for any measured stack power delivery, liquid

water injection rate into the water injection manifold and / or gas flow rate in the oxidant supply manifold are controlled to ensure that there is more liquid water at all regions of the cathode surfaces of all cells than can be evaporated in the prevailing temperature and pressure conditions.

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17. An electrochemical fuel cell assembly comprising:

at least one anode fluid flow field plate having fluid flow channels therein;

at least one ion transfer membrane;

10 at least one cathode fluid flow field plate having fluid flow channels therein;

means for delivering fluid fuel to the anode fluid flow channels;

means for delivering fluid oxidant to the cathode fluid flow channels;

15 a water injection mechanism for delivering a sufficient quantity of liquid water to the fluid flow channels within the cathode such that a relative humidity of 100 % is maintained substantially throughout the fluid flow channels during normal operating conditions of the fuel cell.

18. The assembly of claim 17 in which the water injection mechanism
20 comprises a pump and a controller.

19. The assembly of claim 18 in which the controller includes a voltage sensor for sensing fuel cell or fuel cell stack voltage.

25 20. The assembly of claim 19 in which the controller is adapted to operate in a calibration mode comprising determining a maximum in cell voltage as a function of liquid water flow rate for each of a plurality of normal cell or cell stack operating currents.

21. The assembly of claim 20 in which the calibration mode further comprises determining a calibration function expressing minimum liquid water flow rate as a function of current and air stoichiometry.
- 5 22. The assembly of claim 18 further including a current sensor for sensing current flow through the fuel cell or fuel cell stack, and in which the controller is adapted to control water injection rate to maintain delivery of a water factor $WF > 1.0$ for all fuel cell or fuel cell stack currents within a normal operating range.
- 10 23. The assembly of claim 22 in which the controller is adapted to control water injection rate to maintain delivery of a water factor of at least 1.5.
24. The assembly of claim 23 in which the controller is adapted to control
15 water injection rate to maintain delivery of a water factor of less than 40.
25. The assembly of claim 24 in which the controller is adapted to control water injection rate to maintain delivery of a water factor of at least 3.
- 20 26. The assembly of claim 18 in which the controller is adapted to control water injection rate to maintain delivery of a water factor in the range from 3 to 6.
- 25 27. The assembly of any one of claims 17 to 26 further including means for temporarily permitting delivery of a quantity of liquid water to the fluid flow channels within the cathode such that a relative humidity of less than 100 % is maintained when the cathode exhaust temperature is below a predetermined threshold corresponding to a sub-optimal operating temperature..

28. Apparatus substantially as described herein with reference to the accompanying drawings.

29. A method substantially as described herein with reference to the
5 accompanying drawings.